CLARK FORK RIVER
MACROINVERTEBRATE COMMUNITY BIOINTEGRITY: 2002 ASSESSMENTS

prepared for
Montana Department of Environmental Quality
Planning, Prevention and Assistance Division

prepared by
Daniel L. McGuire
McGuire Consulting

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SUMMARY

The Montana Department of Environmental Quality has conducted annual macroinvertebrate surveys in the Clark Fork River Basin since 1986. Each August, we assessed biological integrity to evaluate water quality at 25 to 28 sites from the headwaters to Thompson Falls Reservoir. Improved water quality in recent years has resulted in increased biological diversity throughout much of Clark Fork River Basin. The majority of monitoring sites were rated as nonimpaired during 2000 and 2001. Consequently, the monitoring program was abridged and only 12 sites were sampled during 2002.

Our analysis was developed specifically for the Clark Fork River drainage and compares each station to a fixed reference condition. The analysis integrates ten measures of macroinvertebrate community structure and composition into a single index of biological integrity. Results are presented on a scale of 0 to 100% with values greater than 90% indicating nonimpairment. In addition, metric subsets estimate the relative severity of metals and nutrient-organic pollution.

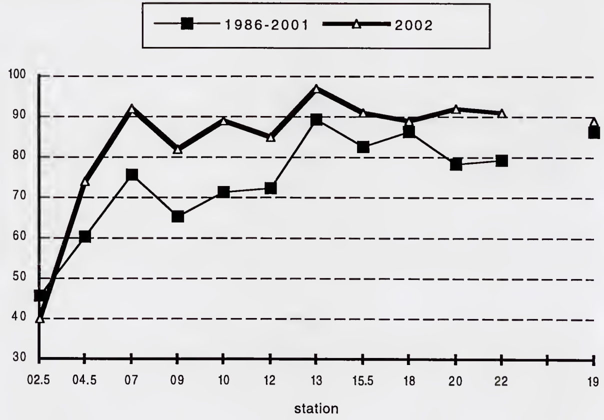
The abridged 2002 biomonitoring program provided adequate coverage of environmental conditions in most of the Clark Fork River Basin. None of the monitored sites exhibited a significant decline in macroinvertebrate community biointegrity compared to previous years.

Benthic macroinvertebrate assemblages were relatively healthy at most sites during 2002. However, pollution was evident at 7 of 12 monitoring stations. Silver Bow Creek at Opportunity remained severely impaired by metals. Significant metals pollution was not detected below the Warm Springs Ponds or at any site on the Clark Fork mainstem. Slight biological impairment attributable to nutrient/organic pollution was evident in Silver Bow Creek below the Warm Springs Ponds, in the lower Bitterroot River, and the Clark Fork River at Bonita. The Clark Fork River from Deer Lodge to the Little Bitterroot River and at Shuffield's (downstream from the Missoula WWTP) were classified as slightly impaired. The cause of impairment at these sites was not diagnosed.

The severity and occurrence of **metals pollution** has been reduced in much of the upper Clark Fork River Basin. Diminishing metals impacts were documented over the past 10 years at all monitoring sites from the Warm Springs Ponds to Missoula. The initial stage of the Milltown Reservoir drawdown during August 2002 did not appear to have an immediate impact on downstream macroinvertebrate communities.

Nutrient and organic pollution are a significant cause of biological impairment in most of the Clark Fork River Basin. However, reduced nutrient impacts and increased biological integrity were evident in the Clark Fork River from the confluence of the Bitterroot River to Huson during the past 4 years.

Mean biointegrity (%) at 12 Clark Fork River Basin monitoring sites during August, 1986-2001 and 2002.



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1. INTRODUCTION

The Montana Department of Environmental Quality (MDEQ) conducts annual macroinvertebrate surveys as part of its environmental surveillance of the Clark Fork River Basin. From 1986 through 2001, biological monitoring was conducted at 28 stations along a 300-mile reach from Silver Bow Creek to Thompson Falls Reservoir. These data provide a detailed understanding of environmental conditions in the Clark Fork River Basin and document significant biological responses to cleanup activities in the upper basin during the past decade (McGuire 1987, 1989a, 1989b, 1993, 1995, 1997-2002; McGuire and Ingman 1996). Improved water quality has resulted in increased biological diversity and the majority of Clark Fork River Basin monitoring sites were rated as nonimpaired during 2000 and 2001 (McGuire 2002). Consequently, the monitoring program was condensed to 12 sites for 2002 and 2003. Macroinvertebrate data from 2002 are presented in this report.

Macroinvertebrates are good indicators of water quality and are commonly used to evaluate environmental impacts to streams. Healthy streams support diverse assemblages of mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), true flies (Diptera), beetles (Coleoptera) and many others. These organisms provide energy pathways from primary producers (algae) and organic material to consumers (fish, humans, etc.). As integral components of stream ecosystems, macroinvertebrate assemblages reflect the cumulative impacts of all pollutants. Toxic substances, organic pollution, and excessive sediment loading produce characteristic changes in the community. These responses can be used to document the type(s) and degree of pollution.

Macroinvertebrate-based assessments can be used to quantify ecosystem health or, its converse, environmental degradation. Biointegrity has been defined as "the capacity of supporting and maintaining a balanced, integrated, adaptive community having species composition diversity and functional organization comparable to that of natural habitat of the region" (Karr and Dudley 1981). This concept has been refined to incorporate both ecological integrity and human values by Meyer (1997) who describes a healthy stream as "an ecosystem that is sustainable and resilient, maintaining its ecological structure and function over time while continuing to meet societal needs and expectations". The analysis used in this report was specifically developed to evaluation aquatic ecosystem health in the Clark Fork River Basin. With the inclusion of the 2002 data, a 17-year database exists for 12 stations.

2. STUDY AREA

The study area includes Silver Bow Creek, approximately 270 miles of the Clark Fork River, and the lower reaches of 9 tributaries (Figure 1). Traditionally, biological monitoring has been conducted at 25 to 28 sites in the basin; however, sampling was abridged in 2002. We collected macroinvertebrates at 12 sites considered representative of the various river reaches (Table 1).

Stream Reaches

For some analyses, the study area is partitioned into ecologically distinct stream reaches. These data were used to summarize environmental health in relatively homogeneous river reaches and to evaluate temporal and longitudinal trends using a scale of miles rather than individual sites. Eight stream reaches are currently recognized. Reaches vary in length from approximately 10 to 70 miles and include from one to four sampling stations. Stream reaches include:

SBC	Upper Silver Bow Creek; from the old Colorado Tailing site to the Warm Springs Ponds. Only the site near Opportunity (station 02.5) was sampled in 2002.
CFR0	Lower Silver Bow Creek (below the Warm Springs Ponds) and the upper Clark Fork River downstream to Sager Lane. Only Silver Bow Creek below the Warm Springs Ponds (station 04.5) and the Clark Fork below Warm Springs Creek (station 09) were sampled in 2002.
CFR1	Clark Fork River from Sager Lane to the Little Blackfoot River.
CFR2	Clark Fork River from the Little Blackfoot River to Rock Creek. Only the Bonita site (station 12) was sampled in 2002.
CFR3	Clark Fork River from Rock Creek to the Blackfoot River.
CFR4	The Clark Fork River from Milltown Dam to the Bitterroot River.
CFR5	Clark Fork River from the Bitterroot River to Alberton.
CFR6	Clark Fork River from Superior to the Flathead River (not sampled in 2002).

Figure 1
Clark Fork Basin Monitoring Project

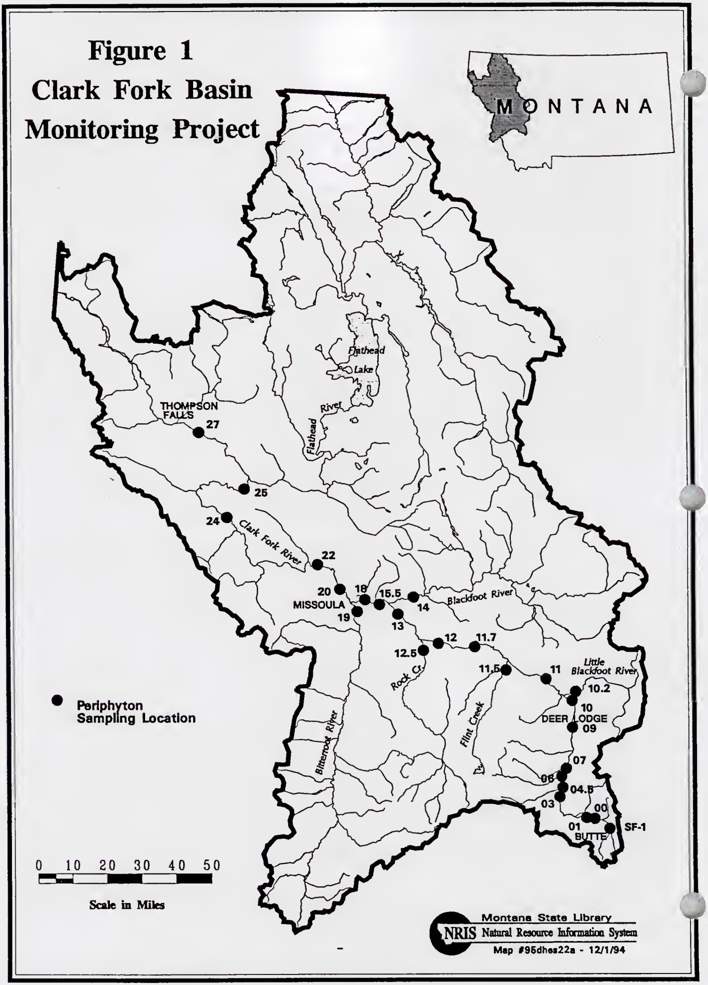


Table 1. Clark Fork Basin biomonitoring sites (sites in bold were sampled in 2002).

station	name	reach	period of record
SF-1	Blacktail Creek above Grove Gulch		1993 - 2001
00	Silver Bow Creek above Butte WWTP	SBC	1987 - 2001
01	Silver Bow Creek at Rocker	SBC	1986 - 2001
02 *	Silver Bow Creek near Ramsay	SBC	1986 - 1992
02.5	**Silver Bow Creek at Opportunity**	SBC	1993 - **2002**
03 *	Silver Bow Creek above Warm Springs Ponds	SBC	1986 - 1992
04 *	Warm Springs Pond #2 discharge		1986 - 1991
04.5	**Silver Bow Creek below Warm Springs Ponds**	CFR0	1993 - **2002**
MW-2	Mill-Willow Creeks Bypass		1986 - 1991, 1999 - 2001
06	Warm Springs Creek near mouth	TRIB	1986 - 2001
07	**Clark Fork River below Warm Springs Creek**	CFR0	1986 - **2002**
08	Clark Fork River near Dempsey	CFR0	1986 - 1992, 1998 - 2001
08.5	Clark Fork River at Sager Lane	CFR0	1990 - 1992, 1998 - 2001
09	**Clark Fork River at Deer Lodge**	CFR1	1986 - **2002**
10	**Clark Fork River above Little Blackfoot River**	CFR1	1986 - **2002**
10.2	Little Blackfoot River near mouth	TRIB	1993 - 2001
11	Clark Fork River at Gold Creek Bridge	CFR2	1986 - 2001
11.5	Flint Creek at New Chicago	TRIB	1993 - 2001
11.7	Clark Fork River at Bearmouth	CFR2	1993 - 2001
12	**Clark Fork River at Bonita**	CFR2	1986 - **2002**
12.5	Rock Creek near Clinton	TRIB	1993 - 2001
13	**Clark Fork River at Turah**	CFR3	1986 - **2002**
14	Blackfoot River near mouth	TRIB	1986 - 2001
15 *	Clark Fork River below Milltown Dam	CFR4	1986 - 1988
15.5	**Clark Fork River above Missoula**	CFR4	1989 - **2002**
16 *	Clark Fork River above Missoula WWTP	CFR4	1986 - 1988
18	**Clark Fork River at Shuffield's**	CFR4	1986 - **2002**
19	**Bitterroot River near mouth**	TRIB	1986 - **2002**
20	**Clark Fork River at Harper Bridge**	CFR5	1986 - **2002**
22	**Clark Fork River at Huson**	CFR5	1986 - **2002**
23 *	Clark Fork River near Alberton	CFR5	1986 - 1992
24	Clark Fork River at Superior	CFR6	1986 - 2001
25	Clark Fork River above Flathead River	CFR6	1986 - 2001
26 *	Flathead River near mouth		1986 - 1988
27	Clark Fork River above Thompson Falls Reservoir		1987 - 2001

* discontinued stations

3. METHODS

3.1 Field Work

Since 1986, DEQ staff and/or Erich Weber and Dan McGuire have collected benthic organisms with a modified Hess sampler (0.1 sq. meter diameter, 1000 micron mesh netting). During August of each year, four replicate samples were obtained from each station. Sampling methods are described in the MDEQ Field Procedures Manual (1996). At each site, samples were obtained from the least embedded, most heterogeneous cobble substrates available. Aquatic and riparian habitat was evaluated at each site above Missoula. Nine parameters were visually rated using the MDEQ Rapid Bioassessment Protocol (RBP) field habitat assessment form.

3.2 Laboratory Analysis

Laboratory processing was consistent with that used in previous years. Samples were rinsed in a U.S. Standard #30 sieve to remove the preservative. A small portion of the sample was placed in a white pan divided into ten equal areas by a grid. All macroinvertebrates were removed and sorted to order. This process was repeated until the entire sample was processed. If the sample clearly contained more than 1000 organisms, subsampling was used to estimate densities of selected abundant taxa (e.g. blackflies or hydropsychids). Samples were processed as usual except that selected taxa were removed from only two randomly selected grids. The number in the subsample was multiplied by five to provide estimated density per 0.1 m^2 Hess sample. Organisms were identified to the lowest level practical, usually genus or species, and enumerated.

3.3 Data Analysis

The analysis was specifically designed to evaluate water quality in the Clark Fork River Basin (McGuire 1993). The analysis incorporates 10 metrics (Table 2) into a single index of biological integrity. The metrics used in the analysis exhibit predicable responses to environmental stress and were the most suitable to the broad range of habitats within the study area. Each metric measured a different aspect of community composition, structure, or function. Since biological communities integrate the effects of all environmental stresses, this analysis provided a reliable evaluation of cumulative impacts from metals, nutrients, and streamflow alteration.

To evaluate stream health, each metric was assigned a score (0 to 6) based on its comparability to the reference criteria. Scores for all metrics were totaled and the sum, expressed as a percentage of the maximum possible score, was used as an estimate of biological integrity. The resulting summary score provides a reliable and easily understandable estimate of ecological health.

Metric scoring criteria reflect the range of values in the Clark Fork River Basin from 1986 through 1990. Data from the first three years (1986-1988) of the Clark Fork River Basin study and two years of data (1988-1989) from the Blackfoot River (Ingman et al. 1990) and Bitterroot River (McGuire 1988b) were used to establish metric scoring criteria. For each metric, statistically significant differences among stations were identified by one-way analysis of variance (McGuire 1987, 1989a, 1989b, 1990a, 1990b, Ingman et al. 1990, and unpublished data). Scoring criteria endpoints were defined by statistically distinct groups of stations with the highest and lowest scores. Nonimpaired endpoints were based on stations with the best metric scores and were generally established as the mean minus one standard deviation. On the lower end of the scale, endpoints were generally based on average values of the most severely impaired station(s).

Scoring criteria for some metrics were adjusted to improve the reliability of assessments for metals pollution. The inclusion of Silver Bow Creek data resulted in wide scoring ranges for most metrics and, consequently, some statistical differences in metric values were not reflected in the scoring criteria. The lower end of the scoring criteria for taxa richness was truncated to provide better discrimination of slight impacts in the Clark Fork River at the expense of detecting slight improvements in Silver Bow Creek. Scoring criteria for percent filterers, Baetidae to Ephemeroptera, Hydropsychinae to Trichoptera, and EPT to EPTC ratio metrics were relaxed to improve the reliability of these metrics over the wide geographic area.

The biointegrity assessment sacrifices some sensitivity to subtle differences to improve reliability. In general, biological integrity in the Clark Fork Basin can be categorized as nonimpaired (90 to 100%), slightly impaired (70 to 90%), moderately impaired (50 to 70%), or severely impaired (<50%). These impairment classifications were less rigorous than statistical differences in the 1986 through 1988 Clark Fork River Basin data. Except for borderline values, scores in different narrative categories are considered significantly difference from one another.

Macroinvertebrate assemblages exhibit predictable responses to different types of environmental stress; consequently, the sensitivity of individual metrics varies with the type of pollution. Some parameters are useful as estimators of metals pollution while others are more sensitive to organic/nutrient enrichment, excessive sediment deposition, or partial dewatering. Both metals and nutrient pollution are known to degrade water quality and impact aquatic life in the Clark Fork Basin (Ingman and Kerr 1990, McGuire 1990). Therefore, subsets of metrics considered sensitive to these forms of pollution were used to estimate the relative severity of each pollutant (Table 2).

Impacts attributable to metals and nutrient/organic pollutants were estimated by the sum of scores for metrics in each subset, expressed as a percentage of the maximum possible score (usually 18). Metrics comprising the nutrient/organic subset were community density, biotic index, and the percent relative abundance of filter-feeding macroinvertebrates. The subset used to estimate metals pollution consisted of community density, EPT richness, and metals tolerance index.

A specific type of pollution was indicated when the score of one set of metrics was substantially lower than the other. To facilitate interpretation, impacts attributable to these pollutants were categorized as slight (~60 to 80%), moderate (~40 to 60%) or severe (< 40%). The more conservative classification scheme for these metric subsets reflects the limitations of an assessment based on only three metrics. The impairment classifications accurately reflect statistical differences in the 1986 through 1988 Clark Fork River Basin data. Except for borderline values, scores in different narrative categories were considered significantly difference from one another. Metrics and the rationale for their use are described as follows.

Macroinvertebrate Density

Total macroinvertebrate density is an important feature of community structure and, when carefully interpreted, can be a useful indicator of several different environmental conditions. Unusually high or low macroinvertebrate densities are considered indicative of environmental perturbation. Macroinvertebrate density tends to increase in response to organic and/or nutrient enrichment, and the magnitude of the increase reflects the degree of the pollution. Conversely, macroinvertebrate density may be reduced by toxic substances such as metals, by severe habitat degradation, or by extensive scouring.

Low macroinvertebrate densities were used as an index of metals pollution in the upper Clark Fork River Basin. Specifically, this metric was included to document toxic impacts and provide a measure of biological improvement in Silver Bow Creek. Historically, macroinvertebrates have been absent from or present at very low densities in Silver Bow Creek and the Mill-Willow Bypass (Spindler 1959, Multitech and OEA Research 1986, McGuire 1990b). Increased macroinvertebrate abundance at these sites can be considered a clear indication of reduced toxicity. This metric typically provides little information regarding environmental health in the remainder of the study area.

High macroinvertebrate standing crops were included as a metric to assess trophic status in the Clark Fork River. Densities greater than 2,000 per sample (0.1 m^2) were attributed to organic pollution and/or enhanced primary production caused by nutrient enrichment. Densities greater than 5,000 per sample receive a metric score of 0. Given that the threshold value is 2,000 organisms per sample, it is not considered a sensitive measure of organic loading in more oligotrophic tributaries. Because toxic conditions can preclude high macroinvertebrate densities (McGuire 1990b), this metric was not used to evaluate organic/nutrient pollution when density was less than 550 organism per sample. Densities between 550 and 2,000 organisms per sample received maximum scores for both density metrics.

Taxa Richness

Taxa richness, or the number of macroinvertebrate taxa per Hess sample, was probably the single best measure of environmental condition in the Clark Fork River drainage. It is a reliable measure of biological integrity because the loss of the most sensitive species to any stress affects the index. The range for scoring this metric was 14 to 40 taxa per sample. This truncated scoring range maximizes the sensitivity of this metric to statistically significant reductions in taxa richness. Mean taxa richness in the lower Blackfoot River during 1988 and 1989 was 41 (Ingman et al. 1990 and McGuire 1990a).

Shannon Diversity

Shannon diversity has long been used as an index of environmental condition (Weber 1973) and is a reliable measure of combined environmental stress in the Clark Fork drainage. This index has two components and is influenced by taxa richness and the distribution of individuals among taxa (evenness). Reference stations in the developmental database had an average Shannon diversity value of 3.7 with a standard deviation of 0.4. For this analysis, values greater than 3.3 were considered nonimpaired.

EPT to Chironomidae Ratio (EPT/EPTC)

This metric, originally developed by the EPA (Plafkin et al. 1989), is based on relative abundance of indicator groups. Most Ephemeroptera, Plecoptera, and Trichoptera are considered sensitive to environmental stresses while Chironomidae, as a group, are more tolerant. In the form (E+P+T) divided by (E+P+T+C), this metric ranges from 0 to 1.

An even distribution of individuals among the four groups reflects good biotic condition while a disproportionate number of chironomids indicates environmental stress. For the Clark Fork analysis, values <0.55 indicate impairment. Using this scale, the EPT/EPTC metric reliably identifies severe biological impairment but does not consistently separate slight, moderate and nonimpaired sites. In some cases, large populations of relatively tolerant EPT taxa (e.g. Baetidae, *Tricorythodes* or hydropsychids) result in high EPT/EPTC values. The percentage Baetidae of Ephemeroptera and percentage Hydropsychinae of Trichoptera metrics are included to identify slight to moderate impairment missed by the EPT/EPTC metric.

Percent Baetidae of Ephemeroptera

Members of the family Baetidae are among the most pollution-tolerant mayflies (Hubbard and Peters 1978). Slight to moderate environmental stress is indicated when baetids comprise most of the mayfly fauna. This metric ranges from 0 to 1 with high values (>0.85) indicating biological impairment. This metric received a default value of 1 when no mayflies were collected.

Percent Hydropsychinae of Trichoptera

The subfamily Hydropsychinae is, in general, more tolerant of pollution than most other caddisflies (Harris and Lawrence 1978). Environmental stress is indicated when most of the caddisflies in a sample are *Hydropsyche* and *Cheumatopsyche*. This metric is analogous to the Baetidae/Ephemeroptera metric and ranges from 0 to 1 with high values (>0.85) indicating biological impairment. When no caddisflies were collected, this metric received a default value of 1.

Biotic Index

The biotic index is based on the indicator organism approach to water quality assessment and was developed to measure organic pollution. The index is calculated: SUM ($\%RA_i * t_i$), where $\%RA_i$ is the percent relative abundance of each taxon and t_i is the tolerance value of the taxon. This index is on a scale of 0 to 10 with higher values indicating more polluted conditions. Tolerance values used in this study (Appendix A) were taken from Hilsenhoff (1987) and McGuire (1992).

Percent Relative Abundance of Filter Feeders

The relative abundance of functional feeding groups can provide useful insights into energy transfer, food resources and organic loading in aquatic ecosystems. Filter feeding insects typically comprise a major component of the summer macroinvertebrate fauna in Montana rivers. Relative abundance greater than 50 percent indicate high seston (suspended organics) concentrations that are usually associated with organic/nutrient enrichment, extensive filamentous algae growth, or lake outflows. This metric is used as a measure of organic pollution in the Clark Fork River Basin. Functional classifications were based on Merritt and Cummins (1984).

EPT Richness

This metric summarizes species richness of Ephemeroptera, Plecoptera, and Trichoptera and was used as an indicator of metals pollution. The majority of mayfly, stonefly and caddisfly species are highly sensitive to pollution. With a few exceptions, species in these groups are among the first to be eliminated by metals toxicity (Wiederholm 1984, Clements 1991). EPT richness averaged 21 among Blackfoot River reference stations. The scoring criteria reflect the wide range of values found within the study area. While minimizing influences of pollutants other than toxins, the wide range reduces the sensitivity of this metric to subtle changes.

Metal Tolerance Index (MTI)

This metric quantifies changes in community composition attributable to metals pollution in the Clark Fork River Basin. The format and calculation are based on Hilsenhoff's biotic index, with tolerance values assigned to each taxon based on sensitivity to metals rather than organics. The index is calculated: SUM ($\%RA_i * t_i$), where $\%RA_i$ is the percent relative abundance of each taxon and t_i is the tolerance value of the taxon. The theoretical scale of the index is 0 to 10 with higher values indicating communities more tolerant of metals pollution. MTI values for communities dominated by species intolerant of metals are less than 4 (i.e. Blackfoot River) while values for communities composed of only the most metals-tolerant species approach 10 (i.e. Silver Bow Creek). Small, but statistically significant differences in metric values are not reflected in assessment scores due to the wide criteria range necessitated by the inclusion of Silver Bow Creek data.

Metals tolerance values (Appendix A) for most taxa were developed from the 1987 and 1988 Clark Fork River Basin water quality (Ingman and Kerr 1989) and macroinvertebrate (McGuire 1987 and 1989a) data. Ingman and Kerr (1989) quantified metals pollution severity for each station based on the frequency and magnitude of measured copper, zinc, cadmium, and lead concentrations exceeding EPA chronic or acute criteria for the protection of aquatic life. Stations were ranked by metals pollution severity. Macroinvertebrate taxa were ranked according to their relative abundance and distributions along this gradient. Abundant taxa (comprising at least five percent of the fauna at any station) were assigned a rank corresponding to the station where they attained their maximum relative abundance. For less abundant taxa, ranks corresponded to the midpoint of their distribution within the study area. Ranks were transformed to a scale of 0 to 10, rounded to the nearest integer, and used as metals tolerance values. Some tolerance values, particularly for infrequently collected taxa, were modified based on the author's interpretation of pertinent literature (Clements 1991, Clements et al. 1988, Rolin 1988, Wiederholm 1984, Winner et al. 1980, Yasuno et al. 1985, Lynch et al 1988, Leland et al 1989).

Trend Analysis

Longitudinal and temporal trends in biological integrity within the Clark Fork River Basin were evaluated at several levels of resolution. Spearman rank correlation (Zar 1974) was used to identify temporal trends in biointegrity. Correlation coefficients (r_s) were calculated to identify temporal trends at individual stations, within stream reaches, and for the study area as a whole. For most stations, analyses were based on 68 samples obtained over 17 years. The fixed reference for all stations and years facilitated this trend analysis.

Table 2. Metrics and criteria used to determine biological integrity in the Clark Fork River Basin.

Metric	Scoring Criteria						
	6	5	4	3	2	1	0
General							
Taxa richness	>39	39-35	34-30	29-25	24-20	19-15	<15
Shannon diversity	>3.3	3.3-3.0	2.9-2.6	2.5-2.2	2.1-1.8	1.7-1.4	<1.4
EPT/EPTC	>.54	.54-.45	.44-.35	.34-.25	.24-.15	.14-.05	<.05
Hydropsychinae/Trichoptera	<.85	.85-.87	.88-.90	.91-.93	.94-.96	.97-.99	1.00
Baetidae/Ephemeroptera	<.85	.85-.87	.88-.90	.91-.93	.94-.96	.97-.99	1.00
Organic pollution subset							
Density	550-1999	2000-2599	2600-3199	3200-3799	3800-4399	4400-4999	>5000
Biotic index	<4.0	4.0-4.5	4.6-5.1	5.2-5.7	5.8-6.3	6.4-6.9	>6.9
% Filterer	<51%	51-55%	56-60%	61-65%	66-70%	71-75%	>75%
Metals pollution subset							
Density	>549	549-450	449-350	349-250	249-150	149-50	<50
EPT richness	>21	21-18	17-14	13-10	9-6	5-2	<2
Metals Tolerance Index	<4.0	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	>8.9

All values are per 0.1 m2 Hess sample. Each metric was scored from 0 (severe impact) to 6 (no impact).

Biointegrity was estimated as the sum of metric scores divided by the maximum possible score.

Numerical criteria for the assessment of biologically significant environmental degradation.

classification	% biointegrity	metric subsets indicating metals or organic pollution
nonimpaired	>90%	>80%
slightly impaired	70-90%	60-80%
moderately impaired	50-70%	40-60%
severely impaired	<50%	<40%

4. RESULTS AND DISCUSSION

Appendix A contains tolerance values for 232 macroinvertebrate taxa found in the study area since 1986. Identifications, organism counts, metric values, and summary statistics for 2002 are presented in Appendix B. For each station, mean metric values, metric scores, and percentage biointegrity assessments were calculated for each year that data were available (Appendix C). The 2002 habitat assessments are contained in Appendix D.

4.1 Stream Discharge

Summer stream flows were about average during August 2002 and were much improved compared to the two previous years (Table 3). Spring runoff was moderate with no sharp spikes. We sampled below Milltown Dam (station 15.5) the morning of August 15th, as the reservior was being drawn down. Stream flow was relatively high and the water was extremely turbid. All other sites were sampled on a stable hydrograph and generally favorable conditions.

4.2 Habitat Assessment

Aquatic and riparian condition was evaluated using the MDEQ Rapid Bioassessment Habitat Field Evaluation (Bukantis 1998). Based on visual observations, 9 habitat parameters were rated (Appendix D). These data do not represent quantitative habitat assessments. However, they provide a means of ranking stations by overall habitat quality and help to identify specific habitat problems.

Overall habitat condition was classified as optimal at most sites during 2002. Habitat scores tended to be higher than in previous years due to improved (higher) stream flows during August. Riparian vegetation also appeared to be generally healthier in 2002 than in 2001. Overall habitat quality was rated as optimal (>124) at 8 sites and sub-optimal (124-92) at 4 sites. Clark Fork River sites below Warm Springs (station 7) and downstream from Rock Creek (stations 13, 15.5, 18, 20 and 22.) were classified as optimal. Silver Bow Creek below the Warm Springs Ponds (station 04.5) was also classified as having optimal overall habitat conditions.

Habitat quality was considered sub-optimal at all Clark Fork River sites from Deer Lodge to Bonita (stations 09, 10, and 12). Relatively high cobble embeddedness, excess sediment deposition and a high percentage of coarse sand were evident at all sites in the upper basin. Significant bank erosion was evident from the lower Deer Lodge Valley to Bonita (stations 10 and 12). Silver Bow Creek at Opportunity (station 02.5) had the poorest overall habitat. In addition to substrate limitations, poor riparian conditions were evident at this site.

4.3 Community Composition and Structure

Macroinvertebrate assemblages have become more diverse and complex during the past 10 years. This trend continued during 2002. Taxa richness, EPT richness, and Shannon diversity were above average for most stream reaches (Table 4). A total of 132 taxa were identified from the 2002 samples. Of these, 22 taxa attained relative abundance's of 5 percent or more at individual stations (Appendix B). These included 8 caddisflies, 4 mayflies, 2 beetles, 7 midges, blackflies, and a scud. Caddisflies were the most abundant macroinvertebrates at all but one monitoring site. Riffle beetles and scuds were the most numerous macroinvertebrates collected from the Clark Fork River below Warm Springs Creek (station 07). Hydropsyschids were the numerically dominant caddisflies at all sites except Deer Lodge (station 09) which supported large populations of hydrotilids. Dipterans were abundant throughout the study area. Elmid beetles were co-dominants in much of the upper river (stations 04.5, 07, 09, and 10). Mayfly relative abundance generally increased in a downstream direction, comprising approximately 30% of the fauna at sites below the Bitterroot River confluence (stations 20 and 22).

4.4 Community Biointegrity during 2002

The overall affect of water quality on macroinvertebrate assemblages was estimated from the composite score of 10 metrics (Table 2). For discussion purposes, bioassessment scores are categorized as nonimpaired (90 to 100%), slightly impaired (70 to 89%), moderately impaired (50 to 69%), or severely impaired (<50%).

Biointegrity was nonimpaired at 5 monitoring sites, slightly impaired at 6 sites, and severely impaired at 1 site during 2002. Bioassessment scores (Table 5) ranged from 40% in Silver Bow Creek at Opportunity (station 02.5) to 97% in the Clark Fork River at Turah (station 13). Severe biological impairment was restricted to upper Silver Bow Creek (Figure 2). Slight biological impairment was indicated in Silver Bow Creek below the Warm Springs Ponds (station 04.5) and in the Clark Fork River from Deer Lodge to Bonita (stations 09, 10 and 12). In the lower portion of the study area, the Bitterroot River (station 19) and the Clark Fork at Shuffield's (station 18) had biointegrity scores of 89% and were classified as slightly impaired.

Metals pollution was indicated at only 1 station in 2002 (Table 5). Composite scores for metals-sensitive metrics ranged from 83% to 94% for all stations except Silver Bow Creek at Opportunity (station 02.5) which scored 33% and was severely impaired by metals.

Nutrient/organic pollution was indicated at 4 sites during 2002 (Table 5). Scores for the metrics most responsive of these pollutants ranged from 67 to 94%. Slight impairment was indicated in Silver Bow Creek at Opportunity (station 02.5) and below the Warm Springs Ponds (station 04.5). Slight nutrient/organic pollution was also indicated in the Clark Fork River at Bonita and in the lower Bitterroot River (stations 12 and 19, respectively).

4.5 Long-term Monitoring

Benthic macroinvertebrate assemblages were relatively healthy throughout the Clark Fork River in 2002. Biointegrity scores were higher in 2002 than the long-term averages (Summary Figure) for all sites except Silver Bow Creek at Opportunity (station 02.5). For all 12 stations combined, annual mean biointegrity (84%) was the third highest on record (Table 6). Mean biointegrity for the 12 sites averaged 75% for the 17-year monitoring period. Significant temporal trends of improved biointegrity were evident at 9 monitoring sites (Figure 3). Trends were strongest at stations immediately downstream from the Warm Springs Ponds (stations 04.5 and 07).

Nutrient and organic pollution are major pollutants in the Clark Fork River Basin (McGuire 2002). Long-term mean values for the subset of metrics most sensitive to these pollutants indicate slight biological impairment at all but 1 of the stations monitored during 2002 (Table 7). However, significant trends of reduced impacts attributable to these pollutants were evident at 6 sites (Figure 4). Improvement was evident below the Warm Springs Ponds (stations 04.5 and 07), and in the Clark Fork from Rock Creek to Missoula (stations 13 and 15.5) and downstream from the Bitterroot River (stations 20 and 22). The only station with a negative Spearman rank correlation coefficient was the Clark Fork River at Shuffield's which is the first monitoring site below the Missoula WWTP.

Metals pollution has diminished in the much of Clark Fork River Basin since 1993 (McGuire 2002). Except for upper Silver Bow Creek, significant metals pollution has been indicated only once in the study area since 2000. The Clark Fork River at Deer Lodge was considered slightly impaired by metals during 2001. Significant temporal trends of reduced metals impacts were evident at all sites from the Warm Springs Ponds to Missoula (Table 8, Figure 5). These trends were strongest at sites immediately below the Warm Springs Ponds and the Mill-Willow Bypass (stations 04.5 and 07).

4.6 Site-Specific Assessments

Silver Bow Creek at Opportunity (station 02.5)

Silver Bow Creek at Opportunity was severely impaired by metals pollution in 2002. Biointegrity was estimated at 40% with a metals subset score of 33%. The sparse macroinvertebrate assemblage was dominated by a few metals-tolerant midge and caddisfly species.

Data from stations 03 (discontinued after 1992) and 02.5 were used to evaluate temporal trends in this portion of Silver Bow Creek (Figure 6). This reach has been classified as severely impaired each year except 1994, 1996, 2000 and 2001. Biointegrity has averaged 45% during the past 17 years.

Silver Bow Creek below the Warm Springs Ponds (station 04.5)

Silver Bow Creek below the Warm Springs Ponds was classified as slightly impaired by nutrient/organic pollution during 2002. Biointegrity was estimated at 74%.

Water quality has improved at this site during the past 9 years. Prior to 1993, Silver Bow Creek below the Warm Springs Ponds was severely impaired by metals, nutrient and organic pollution. However, metals pollution has been reduced in recent years and biointegrity has improved significantly (Figure 7). Biointegrity scores have been higher each of the past 4 years than at any time since monitoring began in 1986. This is the third consecutive year that significant metals pollution has not been indicated at this site (Table 8). Taxa richness, EPT richness, and diversity have increased significantly since 1992. The metals tolerance index has declined from an average of 5.4 prior to 1993 to an average of 4.5 since 1999 (Appendix D-2). Nutrient and organic loading from the pond outflow appears to be the principal factor limiting biological integrity at this site.

Clark Fork River below Warm Springs Creek (station 07)

Biointegrity has improved dramatically at the uppermost station on the Clark Fork River (Figure 8) and was nonimpaired (94%) in 2002. Metals pollution has diminished (Table 8) while biological integrity has increased (Table 6) since reclamation and restoration activities in the Warm Springs Ponds, Mill-Willow Bypass, and Warm Springs Creek were completed in 1993. From 1986 through 1992, this site was moderately impaired and had the lowest biointegrity (60%) in the Clark Fork River. Biointegrity was slightly impaired from 1993 through 1996, but was classified as nonimpaired during 4 of the last 5 years. Metals pollution was detected at this site on all dates prior to 1993, but has been indicated only once (1995) in the past 9 years.

Clark Fork River at Deer Lodge (station 09)

The Clark Fork River at Deer Lodge was slightly impaired in 2002. Biointegrity was estimated at 82%; however, neither metals nor nutrient/organic pollution were clearly indicated (Figure 9). Both metric subsets scored 83%. The macroinvertebrate community has become more diverse at this site in the past 4 years and biointegrity estimates have increased accordingly (Appendix C-4).

This site has the lowest average biointegrity (66%) in the Clark Fork River and has been classified as moderately impaired during 10 years and slightly impaired during 7 years. Slight metals pollution has been indicated during 13 of the past 17 years but only once in the last 3 years. Nutrient/organic pollution, along with partial dewatering, appeared to typically have a greater impact on biointegrity.

Clark Fork River above Little Blackfoot River (station 10)

The biointegrity estimate for the Clark Fork River above the Little Blackfoot was borderline between nonimpaired and slightly impaired in 2002. Biological integrity was estimated at 89% with neither nutrient/organic (89%) nor metals pollution (83%) indicated. This is the highest biointegrity estimate ever recorded at this site (Figure 10).

This site has been impaired throughout the 17-year period of record. Metals and nutrient/organic pollution were routinely detected. Nutrient/organic pollution and habitat degradation, accentuated by low stream flow, were the most significant causes of impairment. However, slight metals pollution was indicated during 11 years and moderate impacts attributable to metals were indicated during 1997. The 1997 biointegrity estimate (48%) and the metals subset score (44%) were the lowest recorded at any Clark Fork River site since monitoring began. The 2000, 2001, and 2002 assessment scores were substantially higher than the 17-year average (biointegrity 72%; metals subset 77%; nutrient/organic subset 66%) for this site.

Clark Fork River at Bonita (station 12)

The Bonita site was classified as slightly impaired (85%) by nutrient/organic pollution (72%) in 2002. Biointegrity was well above the long-term average of 72%. Annual biointegrity estimates are highly variable at this site, ranging from moderately impaired (56%) to nonimpaired (97%) during the monitoring period. High variability may be due to unstable habitat conditions in this reach. Slight to moderate nutrient/organic pollution has been indicated during 14 of the past 17 years (Figure 11). Slight metals pollution was indicated 6 times between 1986 and 1992, but has been indicated only once (1997) since 1992.

Clark Fork River at Turah (station 13)

Biointegrity was nonimpaired (97%) at Turah for the fifth straight year. This site has the highest average biointegrity in the Clark Fork River (90%) and, based on long-term mean biointegrity values, is the only mainstem site classified as nonimpaired. Biological integrity has been nonimpaired each year since 1992 except 1997 (Figure 12). Slight metals pollution was indicated at this site in 1986, 1990, and 1997 while nutrient and organic pollution was indicated in 1987, 1988, 1990 and 1992.

Clark Fork River above Missoula (station 15.5)

We sampled this site, located approximately 1.5 miles below Milltown Dam, during the morning of August 15th as the reservoir was being drawn down. Flows were relatively high and the water was extremely turbid. There were no clear indications of acute impacts to the benthic community from the initial pulse of sediments released from the reservoir. Macroinvertebrate community biointegrity was rated as nonimpaired (91%). Biointegrity has average 83% during the 14-year period of record. Slight to moderate nutrient-organic pollution was usually evident (Figure 13). Metals pollution has not been indicated at this site since 1990.

Clark Fork River at Shuffield's (station 18)

Biointegrity was estimated at 89% in the Clark Fork River at Shuffield's during 2002. However, the biointegrity classification of slightly impaired was equivocal and neither nutrient/organic (83%) or metals (89%) pollution were clearly indicated. Biointegrity was similar to the 17-year average (86%). Slight nutrient/organic pollution was frequently indicated at this site (Figure 14) which is approximately two miles below the Missoula WWTP discharge. Metals pollution has not been clearly indicated at this site since monitoring began in 1986; however, both the 1997 and 1998 assessments were borderline (78%). We noted increased turbidity attributable to the Milltown Reservoir drawdown at this site during the evening of August 14th.

Bitterroot River near mouth (station 19)

Biointegrity was estimated at 89% and considered slightly impaired due to nutrient/organic pollution (78%) in the lower Bitterroot River during 2002. Biointegrity has averaged 87% since 1986. Nutrient/organic pollution has been indicated during 11 of the past 17 years (Figure 15). Metals pollution has not been indicated at this site.

Clark Fork River at Harper Bridge (station 20)

The Clark Fork at Harper Bridge was classified as nonimpaired for the 4th consecutive year. Biological integrity was estimated at 92%. Biointegrity scores have improved significantly at this site since 1999 (Figure 12). Nutrient/organic pollution was indicated at Harper Bridge on all dates prior to 1999 (Figure 16). Impacts were generally slight, although moderate impacts were indicated in 1988 and 1993. This site has the lowest long-term mean biointegrity (79%) among stations from Missoula to the Flathead River.

Clark Fork River at Huson (station 22)

For the 2nd consecutive year, the Clark Fork River at Huson was classified as nonimpaired (91%). Prior to 2001, biointegrity had been slightly to moderately impaired on all dates. The long-term average for this site is 80%. Nutrient/organic pollution was not indicated in 1999, 2001 or 2002 but was evident on all other dates (Figure 17). This site was not sampled in 2000 due to access and fire restrictions. Biointegrity was moderately impaired in 1986, 1988, and 1994 and slightly impaired on all other dates.

Table 3. Mean streamflows during August at selected USGS gaging stations in the Clark Fork River Basin (cubic feet per second).

year	Silver Bow Creek blw Blacktail Cr. USGS # 12323250	Clark Fork River at Deer Lodge USGS # 12324200	Clark Fork River below Missoula USGS # 12353000	Clark Fork River near Plains USGS # 12389000
1986	19.5	55.7	1812	7612
1987	27.7	88.5	1473	9813
1988	18.7	**27.8**	**997**	**5656**
1989	22.0	81.7	2464	14750
1990	25.8	84.3	2554	10510
1991	16.4	30.1	1997	10350
1992	14.2	40.1	1280	9738
1993	**28.7**	312	**3696**	11770
1994	16.1	36.3	1295	5891
1995	21.8	107	2561	10360
1996	18.7	95.2	2766	16530
1997	27.5	**337**	3620	**17700**
1998	24.6	117	2890	13700
1999	22.4	93.4	2625	13420
2000	14.5	34.5	1145	9010
2001	**14.0**	42.1	1865	6589
2002	17.2	92.4	2417	12350
mean	20.6	99	2203	10926

high and low **flows in bold**

Table 4. Mean metric values characterizing macroinvertebrate assemblages in eight Clark Fork River Basin stream reaches during August, 1986 through 2002 (ranges in parentheses).

	SBC		CFR0		CFR1		CFR2		CFR3		CFR4		CFR5		Bitterroot	
metric	1986-2001 (range)	2002	1986-2001 (range)	2002	1986-2001 (range)	2002	1986-2001 (range)	2002	1986-2001 (range)	2002	1986-2001 (range)	2002	1986-2001 (range)	2002	1993-2001 (range)	2002
Density	267	240	1993	1877	2018	1527	2120	2025	1695	1128	1146	1308	1524	575	941	1036
	(82-640)		(896-2956)		(327-3249)		(293-8080)		(226-5635)		(492-2041)		(198-3733)		(334-1870)	
Taxa richness	12	12	31	40	29	34	33	41	39	41	37	39	34	36	35	41
	(5-19)		(18-46)		(22-40)		(23-47)		(26-50)		(28-45)		(26-44)		(29-41)	
EPT richness	4	4	13	17	14	16	17	20	22	24	20	19	18	20	19	20
	(3-8)		(7-20)		(10-19)		(13-25)		(16-26)		(16-25)		(16-22)		(14-22)	
S. Diversity	2.2	1.8	2.8	3.6	2.8	3.8	2.8	3.2	3.8	4.3	3.5	3.5	3.2	3.6	3.6	3.6
	(1.2-2.9)		(2.0-3.9)		(1.9-3.9)		(2.2-3.8)		(3.1-4.6)		(2.9-4.0)		(2.2-4.1)		(2.9-4.3)	
EPT/EPTC	0.47	0.71	0.85	0.85	0.85	0.83	0.86	0.86	0.74	0.70	0.78	0.82	0.76	0.85	0.81	0.77
	(.11-.75)		(.66-.98)		(.68-.95)		(.64-.95)		(.61-.92)		(.53-.91)		(.52-.94)		(.68-.92)	
Baetidae/	0.97	1.00	0.79	0.70	0.73	0.63	0.73	0.72	0.48	0.43	0.59	0.46	0.56	0.07	0.38	0.26
Ephemeroptera	(.75-1.00)		(.19-1.00)		(.29-1.00)		(.13-.98)		(.22-.87)		(.30-.90)		(.12-.90)		(.08-.84)	
Hydropsychinae/	0.73	0.96	0.89	0.72	0.88	**0.51**	0.90	0.89	0.79	0.77	0.83	0.83	0.85	0.85	0.81	0.87
Trichoptera	(.16-.99)		(.51-1.00)		(.57-1.00)		(.72-.99)		(.45-.96)		(.47-.95)		(.45-.98)		(.44-.96)	
% Filterer	47	70	56	34	64	34	61	60	46	39	56	56	57	49	59	57
	(12-77)		(22-84)		(35-81)		(33-80)		(22-68)		(32-75)		(24-74)		(35-81)	
Biotic index	4.2	3.2	5.1	5.3	5.0	4.9	4.9	5.1	4.5	4.5	4.6	4.8	4.7	4.4	4.4	4.6
	(3.0-5.4)		(4.7-5.5)		(4.8-5.4)		(4.4-5.2)		(3.8-5.1)		(4.2-5.2)		(3.6-5.3)		(3.6-4.9)	
Metals index	7.3	6.7	5.1	4.5	5.1	**4.5**	4.8	4.8	4.5	4.4	4.5	4.6	4.6	4.0	4.2	4.5
	(6.0-8.6)		(4.4-5.8)		(4.7-5.6)		(4.2-5.2)		(3.5-5.3)		(4.0-5.7)		(3.3-5.3)		(3.1-4.9)	

Stream reaches: SBC = station 02.5; CFR0 = 04.5, 07; CFR1 = 09, 10; CFR2 = 12; CFR3 = 13; CFR4 = 15.5, 18; CFR5 = 20, 22; Bitterroot River = 19.

2002 values in bold were outside established ranges.

Table 5. Macroinvertebrate community biointegrity estimates for Clark Fork River Basin stations during August, 2002.

	% Biointegrity		
Station	overall	metals subset	organic subset
Silver Bow Creek			
02.5	40 ***	33 ***	67 *
Clark Fork River			
04.5	74 *	83	72 *
07	92	89	83
09	82 *	83	83
10	89 *	83	89
12	85 *	89	72 *
13	97	94	94
15.5	91	89	78
18	89 *	89	83
20	92	89	92
22	91	94	89
Tributaries			
19	89 *	89	78 *

Classification : slightly impaired *, moderately impaired **, severely impaired ***.

Table 6. Mean macroinvertebrate biointegrity (%) and Spearman rank correlation coefficients (rs) for Clark Fork River Basin monitoring stations - August, 1986-2002.

station	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Mean	S.D.	C.V.(%)	rs	P value
Silver Bow Creek																						
02.5	38	40	35	50	43	43	43	47	55	43	50	38	45	50	52	57	40	45	6	14	.32	.009
Clark Fork River																						
04.5	45	44	44	47	41	45		71	70	59	62	58	61	83	88	88	74	61	16	27	.83	.000
07	59	64	53	59	55	65	65	83	82	88	77	94	86	94	92	94	92	77	15	20	.86	.000
09	52	65	62	73	61	83	55	86	53	58	55	55	55	68	79	86	82	66	13	19	.25	.04
10	52	68	71	80	79	86	68	87	59	74	65	48	59	77	82	86	89	72	13	17	.27	.03
12	64	80	58	76	61	64	56	89	76	74	70	57	76	97	68	94	85	73	13	17	.37	.002
13	88	80	76	88	86	92	83	95	89	94	94	82	91	98	94	97	97	90	6	7	.55	.000
15.5	76	88	86	77	68	79	80	90	82	83	85	71	82	95	91	88	91	83	7	9	.41	.001
18	73	88	91	80	86	91	83	95	80	94	86	78	79	95	88	94	89	86	7	8	.27	.03
20	71	77	61	79	73	79	76	61	79	82	76	83	76	92	95	95	92	79	10	13	.65	.000
22	62	86	68	89	88	71	74	85	68	79	75	78	82	88		95	91	80	10	12	.41	.001
Tributaries																						
19	79	83	82	91	85	86	79	90	73	98	85	87	92	93	86	94	89	87	6	7	.38	.001
All stations	63	72	66	74	69	74	69	82	72	77	73	69	74	86	83	89	84	75	7	10	.74	.001

Table 7. Macroinvertebrate biointegrity (%) as measured by metrics* sensitive to organic pollution and Spearman rank correlation coefficients (rs) for Clark Fork River Basin stations - August, 1986-2002.

station	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Mean	S.D.	C.V. (%	rs	P value
Silver Bow Creek																						
02.5	83	83	33	100	83	75	42	92	61	92	75	92	92	100	67	83	67	78	19	24	.09	.46
Clark Fork River																						
04.5	50	56	44	39	39	56		83	72	56	50	33	33	78	72	72	72	57	17	29	.47	.000
07	72	72	50	78	56	72	83	83	83	83	67	89	67	89	83	83	83	76	11	15	.48	.000
09	56	67	50	61	44	83	50	89	50	50	39	50	44	44	61	78	83	59	16	27	.06	.64
10	39	61	56	83	67	89	67	83	50	67	50	58	56	61	67	78	89	66	14	22	.14	.25
12	72	83	33	67	61	50	44	89	72	67	72	58	72	94	39	83	72	66	17	26	.11	.39
13	89	67	44	89	83	83	67	92	89	89	83	92	89	94	83	94	94	84	13	16	.45	.000
15.5	72	75	81	58	42	78	83	100	78	67	72	61	67	100	89	83	78	76	14	19	.30	.02
18	67	89	94	78	72	89	61	89	61	89	67	50	78	89	67	83	83	77	13	17	-.04	.75
20	67	67	39	78	67	72	61	33	67	67	61	67	61	92	89	94	92	69	17	25	.46	.000
22	61	78	50	89	92	61	61	78	33	67	67	100	75	92		89	89	74	18	24	.48	.000
Tributaries																						
19	72	72	72	83	72	78	67	92	56	94	72	67	83	100	67	94	78	78	12	15	.20	.10
All stations	67	73	54	75	65	74	62	84	64	74	65	68	68	86	71	85	82	71	9	12	.43	.08

* metric subset: biotic index, % filterers and community density.

Table 8. Macroinvertebrate biointegrity (%) as measured by metrics* sensitive to metals pollution and Spearman rank correlation coefficients (rs) for Clark Fork River Basin stations - August, 1986-2002.

station	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Mean	S.D.	C.V.(%)	rs	P value
Silver Bow Creek																						
02.5	22	17	44	28	22	28	50	33	56	22	44	22	28	22	44	33	33	32	11	36	.18	.14
Clark Fork River																						
04.5	61	61	61	67	67	61		72	72	61	72	72	72	78	89	83	83	71	9	13	.84	.000
07	72	72	78	72	72	72	72	83	83	78	83	89	94	89	89	94	89	81	8	10	.85	.000
09	78	78	72	83	72	83	72	78	72	72	78	67	78	78	83	78	83	77	5	6	.30	.01
10	72	78	72	67	78	83	78	78	78	78	83	44	78	78	89	89	83	77	10	13	.46	.000
12	78	83	78	78	72	78	78	83	83	83	83	61	89	94	89	94	89	82	8	10	.50	.000
13	78	89	94	83	78	89	94	94	89	89	94	61	94	100	94	94	94	89	9	10	.47	.000
15.5	83	92	92	72	78	83	83	83	89	94	94	83	94	89	94	89	89	87	6	7	.44	.000
18	83	89	89	83	89	89	94	94	94	89	94	78	78	94	94	94	89	89	6	6	.20	.10
20	83	83	78	78	78	83	83	89	83	89	89	78	94	83	94	89	89	85	5	6	.28	.02
22	83	89	83	89	78	83	83	83	83	83	78	83	83	78		94	94	84	5	6	-.10	.43
Tributaries																						
19	83	89	89	94	83	89	89	78	83	100	89	83	94	83	94	89	89	88	5	6	.07	.59
All stations	73	77	78	75	72	77	80	79	80	78	82	68	81	81	87	85	84	77	5	6	.74	.001

* metric subset: metals tolerance index, EPT richness and community density.

Figure 2. Aquatic macroinvertebrate community biointegrity at 12 stations in the Clark Fork River Basin during August, 2002.

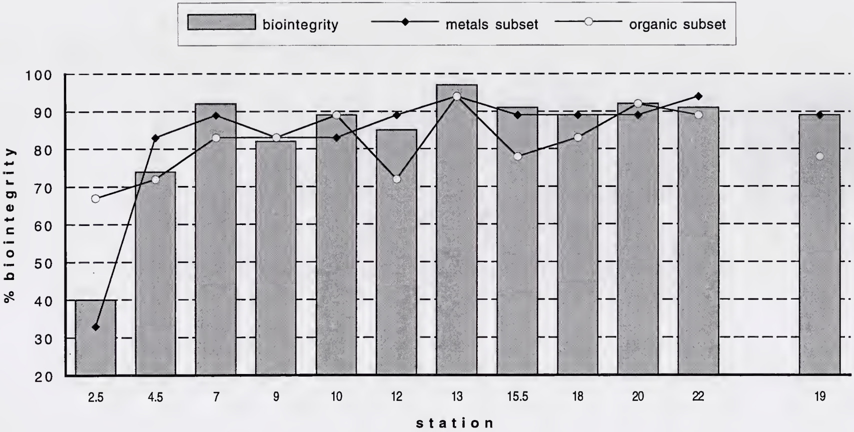


Figure 3. Macroinvertebrate-based biointegrity scores at 12 Clark Fork River Basin stations during the past 17 years (mean +-1 S. D.; left to right:1886-1992; 1993-1997; 1998-2002).

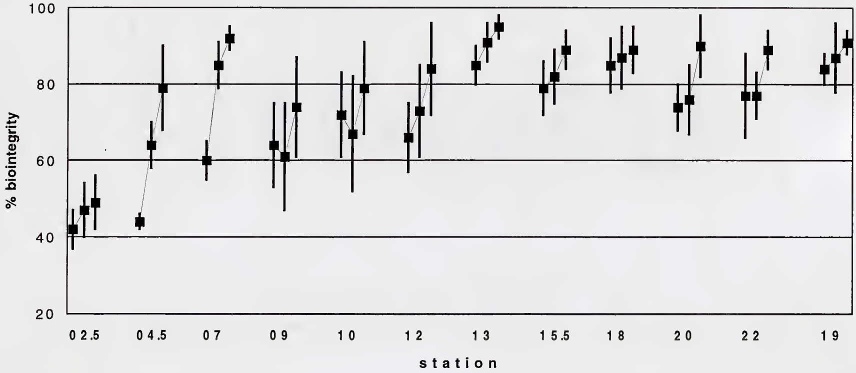


Figure 4. Macroinvertebrate-based nutrient/organic pollution scores at 12 Clark Fork River Basin stations during the past 17 years (mean +-1 S. D.; left to right:1886-1992; 1993-1997; 1998-2002).

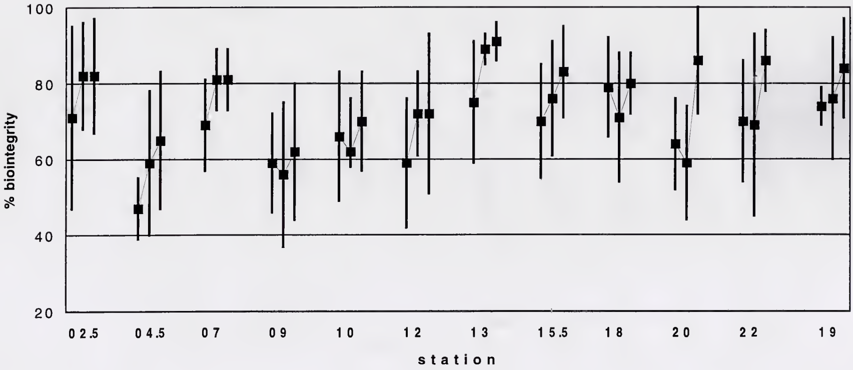


Figure 5. Macroinvertebrate-based metals pollution scores at 12 Clark Fork River Basin stations during the past 17 years (mean +-1 S. D.; left to right:1886-1992; 1993-1997; 1998-2002).

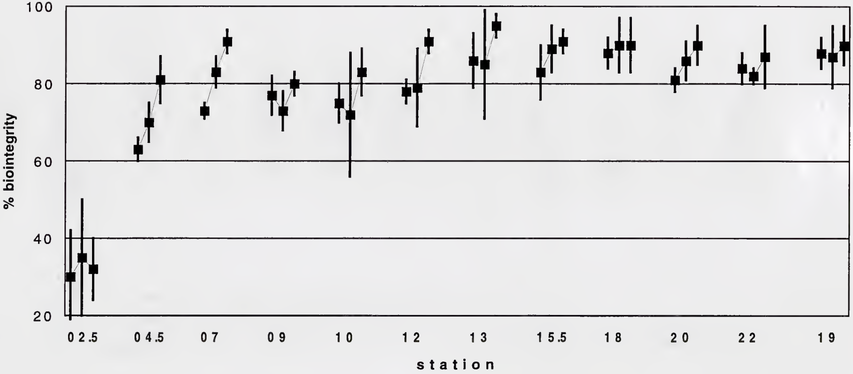


Figure 6. Biointegrity (%) in Silver Bow Creek near Opportunity (station 02.5), 1986-2002.

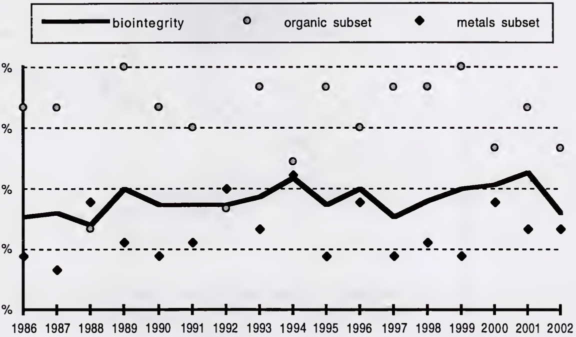


Figure 7. Biointegrity (%) in Silver Bow Creek below the Warm Springs Ponds (station 04, 1986-1991; station 04.5, 1993-2002).

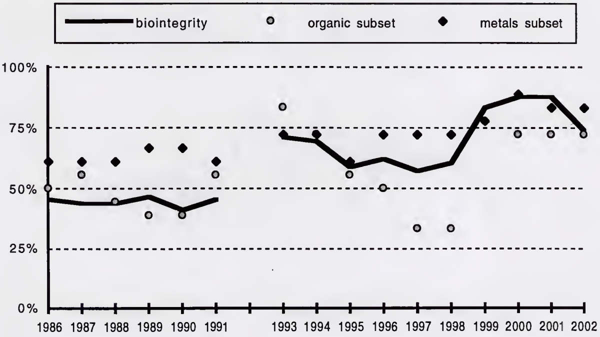


Figure 8. **Biointegrity (%) in the Clark Fork River below Warm Springs Creek (station 07), 1986-2002.**

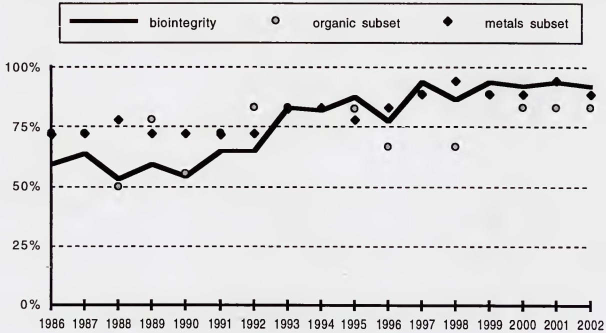


Figure 9. **Biointegrity (%) in the Clark Fork River at Deer Lodge (station 09), 1986-2002.**

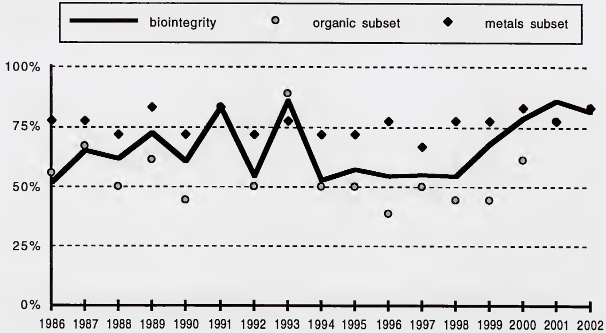


Figure 10. Biointegrity (%) in the Clark Fork River above the Little Blackfoot River (station 10), 1986-2002.

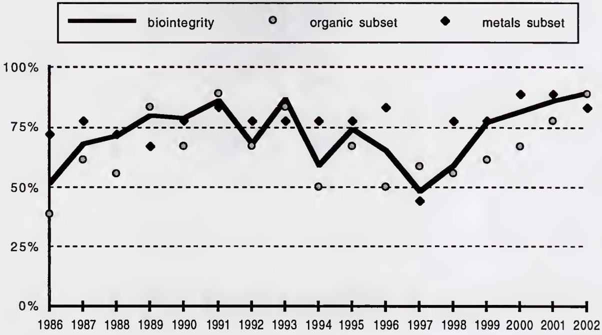


Figure 11. Biointegrity (%) in the Clark Fork River at Bonita (station 12), 1986-2002.

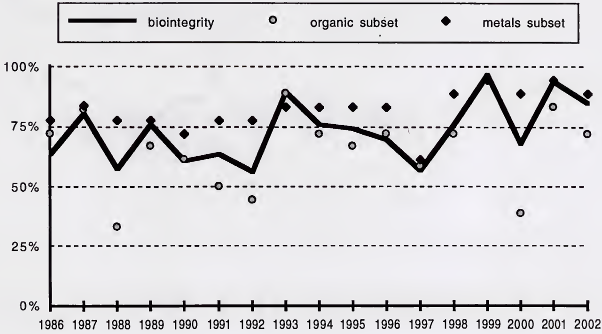


Figure 12. Biointegrity (%) in the Clark Fork River at Turah (station 13), 1986-2002.

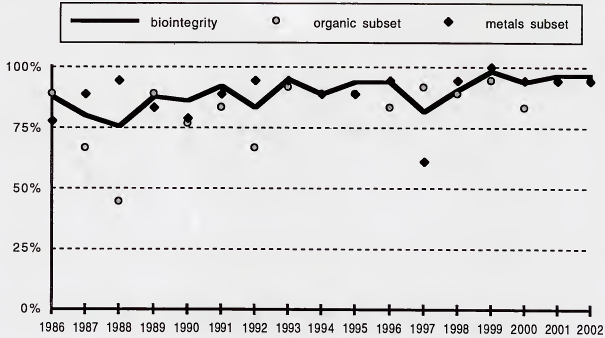


Figure 13. Biointegrity (%) in the Clark Fork River above Missoula (station 15.5), 1989-2002.

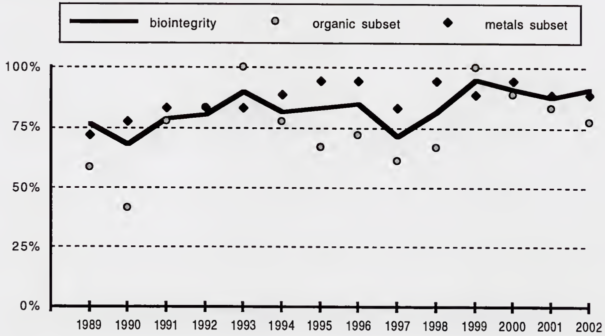


Figure 14. Biointegrity (%) in the Clark Fork River at Shuffields (station 18), 1986-2002.

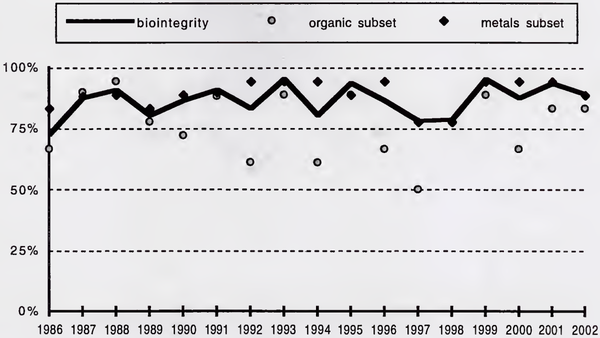


Figure 15. Biointegrity (%) in the Bitterroot River near mouth (station 19), 1986-2002.

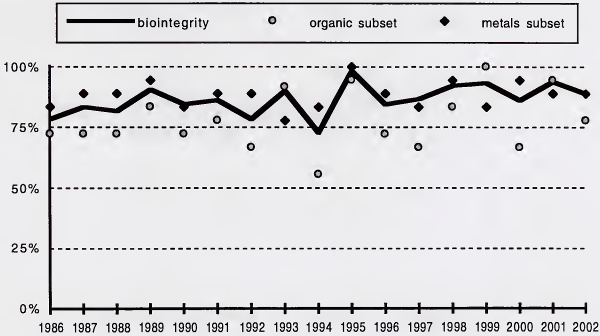


Figure 16. Biointegrity (%) in the Clark Fork River at Harper Bridge (station 20), 1986-2002.

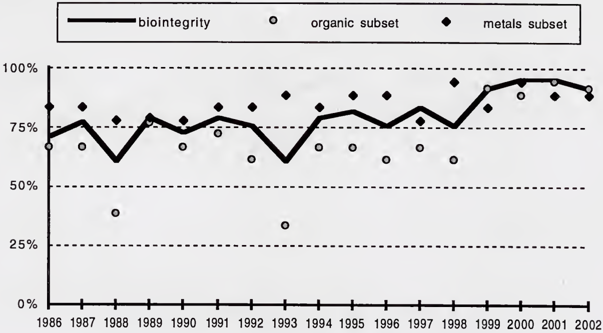
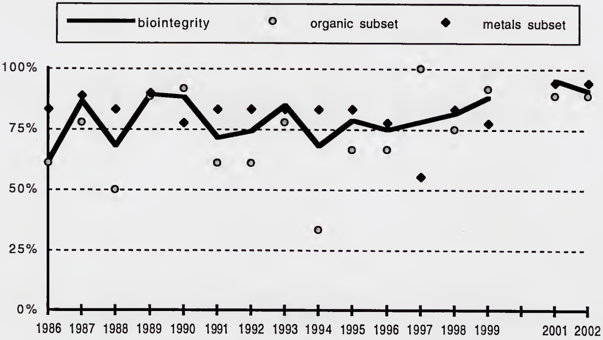


Figure 17. Biointegrity (%) in the Clark Fork River at Huson (station 22), 1986-2002.



5. CONCLUSIONS

1. The abridged biomonitoring program provided adequate coverage of environmental conditions in most of the Clark Fork River Basin.

2. None of the monitored sites exhibited a significant decline in macroinvertebrate community biointegrity during 2002.

3. Macroinvertebrate-based bioassessments indicated no significant water quality problems at 5 Clark Fork River sites during 2002. However, pollution was indicated at 7 monitoring stations.

4. Silver Bow Creek at Opportunity remained severely impaired by metals. Significant metals pollution was not indicated at any other site monitored during 2002.

5. Impacts attributable to nutrient and/or organic pollution were indicated in Silver Bow Creek below the Warm Springs Ponds, in the Clark Fork River Bonita, and in the lower Bitterroot River. Biological impairment was considered slight at these sites.

6. The Clark Fork River from Deer Lodge to the Little Bitterroot River and at Shuffield's (downstream from the Missoula WWTP) were classified as slightly impaired. The cause of impairment at these sites was not diagnosed.

7. The initial stage of the Milltown Reservoir drawdown did not have an immediate impact on downstream macroinvertebrates.

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